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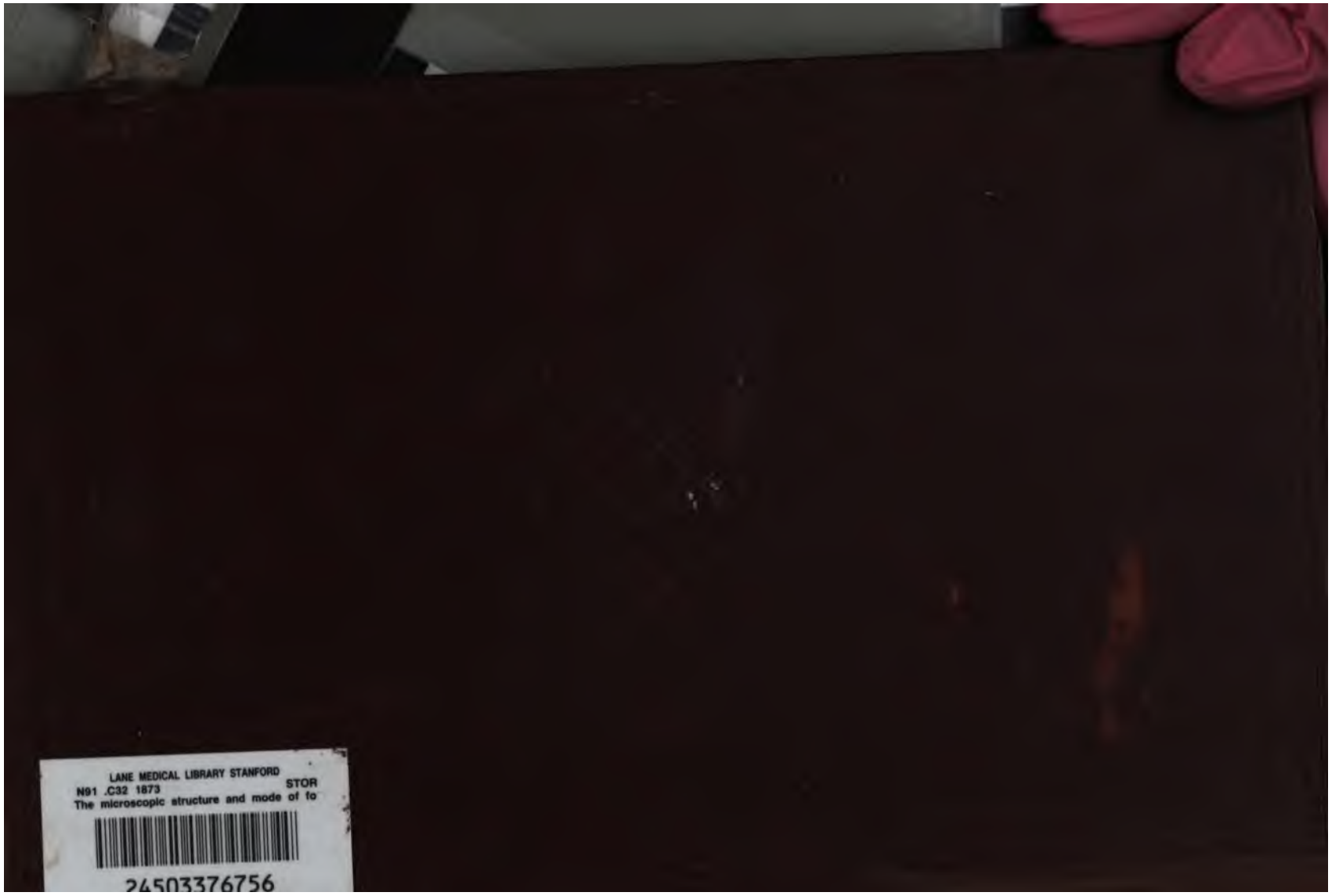
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THE

MICROSCOPIC STRUCTURE

AND

MODE OF FORMATION

OF

URINARY CALCULI

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BY

H. VANDYKE CARTER, M.D. (LOND.)

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PREFACE

It appeared to the author, when he commenced these researches three or four years ago, at a small station in the Deccan plain of Western India, that a blank existed in medical literature which he might do something to fill up; and opportunity presenting itself in a number of 'stone' cases, it was at once pursued, with valuable aid from others in a free and liberal supply of additional specimens. The author's obligations are due to Dr A. Wright, the present head of the Bombay Medical Department, for ready official assistance, and to Drs Holmested, Cates, Beatty, Jayakar, Weir, and to Mr Apothecary Conway; also to Messrs Abdool Kurrim, Dorabji, and Ruttonji, for permission to inspect or retain various interesting calculi. After considerable labour the inquiry terminated in results, which were brought to England in May, 1872, but owing to a variety of circumstances, are not till now published in full.

The author is not aware that hitherto a treatise, or,

indeed, any systematically acquired information, on the subject of the minute structure of urinary calculi in man, has been made known; as an earliest essay, therefore, the present memoir will doubtless prove deficient, but the observations it contains have the advantage of being at first-hand, and it need not be regarded as a valid objection to their interest, that the specimens examined were collected in a tropical climate. It is true, as the author long since determined, that calculi removed from natives of India are somewhat peculiar in chemical composition, and some confirmation of his results has lately appeared, as may be learnt from a short article in the 'St George's Hospital Reports,' vol. vi, 1873; but this feature does not affect the main issues here set forth, and the author, anticipating further inquiries in England, would only venture to recommend such patient pursuit of a subject not particularly amenable to investigation, as he has himself found necessary for its satisfactory elucidation.

It is right to add that Dr Beale's standard work on the urine &c. (third edition) was the only book of reference available to the author in India, and that its aid was most valuable; it will be seen that some of Dr Beale's observations respecting forms of the calcic oxalate are confirmed by these later researches.

With reference to the second part of the present

memoir, namely, that treating of the mode of formation of calculi, no pretence is made to novelty so far as concerns the principle sought to be applied, and the facts upon which that principle is based. It is to Mr Rainey that is due, so far as the author knows, the credit of fully demonstrating the existence and character of that widely operating process termed by him 'molecular coalescence,' which the author here only attempts to apply in explanation of the construction of certain calculous ingredients in man; for details recourse should be had to the experimental parts of Mr Rainey's original work, entitled 'On the Formation of Shells &c.,' London, 1858. To Dr W. M. Ord, also of St Thomas's Hospital, is due an extension of these experimental investigations, which has led to results hardly less interesting than theirs with reference to the subject under notice, and the author (who quite recently met with the paper) would strongly advise a reference to Dr Ord's original communication, entitled "On Molecular Coalescence, and on the Influence exercised by Colloids upon the forms of Inorganic Matter," and published in the 'Quarterly Journal of Microscopical Science' (vol. xii, New Series, 1872, p. 219); and he would suggest a careful comparison of his own figures from natural specimens, with those of Dr Ord from results of experiment. When mention is made of a preliminary communication respecting a work of Professor Harting, of the University of Utrecht, published at p. 118 of the same volume, every

source of special information made use of has been enumerated. For the argumentative portion of the present essay the author is alone responsible.

H. V. C.

June, 1873.

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PART I

THE MICROSCOPIC STRUCTURE OF URINARY CALCULI

About one half the specimens examined were submitted to inspection very soon after their extraction, but I do not know that in them, the internal appearances were in any way different from those observed in calculi, which had been kept for months or years. Copious notes were made of every specimen, which I have preserved; nothing is here stated that has not been seen and carefully scrutinised; and on the other hand, no marked exception was met with to the general results, as now recorded. It was not practicable to add descriptions or figures of the several calculi examined, otherwise this demonstration of their structure would have been more complete; nor is it pretended to have nearly exhausted the subject; on the contrary, there are numerous points well meriting discussion which I have abstained from entering upon in a first essay; such are the probable bases of the uric acid salts, the combinations of the calcium phosphate, and the likely complex composition of some submorphous forms, here attributed to calcium oxalate. The polariscope was frequently employed, but as, on

the whole, its indications were not, in my hands, of a decided character, no mention is made of them.

The plan adopted was as follows :—Each calculus was divided on one side of the middle, the actual centre was then made out as far as possible, and fragments of the nucleus and of succeeding layers, were carefully examined under various optical powers, and with the aid of chemical reagents. Entire sections were made of a few typical specimens, and have been preserved, and especial attention was given to the nature of the nuclear portions or first-formed ingredients of the calculi, as a point of chiefest interest; for it is obviously desirable to ascertain in what form these concretions primarily appear, with a view to their early diagnosis, and to the possible prevention of their increase.

After sufficient practice, it becomes apparent that the microscopic analysis of urinary calculi is not only valuable, but that it is even more delicate than the chemical method; by its aid will be seen still more clearly than before, that no single urinary deposit long occurs alone, and there will be gained a more accurate conception of the real structure of these hurtful concretions.

Respecting the eighty specimens submitted to examination, the following brief details may be appended :

Five of the whole number, or 6 per cent., were removed from the female bladder; 13, or 15 per cent., were urethral, or more rarely renal, calculi from males; 62, or 79 per cent., were vesical calculi extracted by lithotomy from male subjects, whose ages varied from two and a half years to sixty years, about one half, however, being under ten years of age, and but nine

were over forty. No fixed relation appears between the duration of symptoms and the size or composition of the stones.

As respects age there is, however, noticed, as might be anticipated, a large predominance of calculi the nucleus of which was mainly composed of the urates, in patients under twenty years of age; subsequently oxalate of lime is commonest as the nucleus; after forty years of age uric acid is rather more frequent.

In general, of sixty-two vesical calculi the nucleus was composed of urates, mixed with crystals of oxalate, thirty-four times; of oxalate chiefly, twenty-one times; of uric acid chiefly, seven times; these results being accordant with those elicited in my former analyses.[1]

The attached table will exhibit these and other features; in it "Uts." stands for the urates; "O. L." for the oxalate of lime; "T. Ph." for the triple phosphate, and so on; it includes eighty-two calculi, and some others might have been afterwards included, without materially affecting these data.

* An account of the calculi contained in the Museum of the Grant Medical College, Bombay, &c., published in the 'Transactions of the Medical and Physical Society of Bombay,' new ser., vol. v, 1859. See also 'St George's Hospital Reports,' vol. vi, 1873.

TABLE I.—*Showing result of microscopic analysis of Calculi; with data respecting Stone and Patient*
(N.B.—Read from left to right)

No.	Age.	Duration of symptoms.	Weight.	Nucleus.	Body.	Crust.	Locality.	Remarks.
			FEMALE.					
	Yrs.		Oz. drs. gr.					
1	4	1 mo. ?	0 2 28	Uts., O. L.	Uts., O. L.	Uts., O. L.	Deccan	—
	5	—	0 4 10	Uts.	Uts.	Uts.	Bhooj	—
	8	6 yrs.	0 4 30	Uts., O. L.	Uts., O. L.	T. Ph.	Deccan	—
	11	2 yrs.	3 0 0	O. L., Uts.	O. L.	T. Ph., Uts.	Ditto	Spontaneous fracture.
5	17	—	1 4 0	Uts., O. L.	Uts., O. L.	Uts., T. Ph.	Ditto	—
			MALE.					
			(*a*) *Urethral or Renal.*					
1	2	Unknown	—	Uts., O. L.	—	—	Deccan	—
	3	—	—	Uts., O. L.	—	—	—	—
	5	—	—	Uts., O. L.	—	—	—	—
	5	—	—	Uts., O. L.	—	—	—	—
5	7	—	—	Uts., O. L.	—	—	—	—
	Yng.	—	—	O. L.	—	—	—	Uric acid too.
	Do.	—	—	O. L.	—	—	—	—
	12	—	—	O. L.	—	—	—	Several c.
	20	—	—	O. L.	—	—	—	—
10	25	—	—	Uts., O. L.	—	—	—	A large O. L. calculus co-existed.
	26	—	—	Uric acid	—	—	—	—
	36	—	—	O. L.	—	—	—	—
	45	—	—	Uric acid	—	—	—	Gravel.
			(*b*) *Vesical.*					
1	2	4 mos.	0 0 53	Uts., T. Ph.	Uts., O. L.	O. L.	—	—
	2½	Ditto	0 0 47	Uts., mixed	Uric acid	Uts., mixed	—	—
	4	18 mos.	0 1 45	Uts., O. L.	Ditto	Ditto	—	—
	4	12 mos.	0 1 15	Uts., O. L.	Uric a.	Ditto	—	—
5	4	Ditto	0 1 54	Uts., O. L.	Ditto	Ū., mixed	—	—
	5	—	0 2 23	Uts., O. L.	Ditto	Ū., T. Ph.	—	—
	5	12 mos.	0 1 16	O. L.	Uts., O. L.	O. L.	—	—
	5	Ditto	0 0 38	Uts., O. L.	Uric a.	—	—	—
	6	—	0 2 8	Uts., O. L.	Ditto	Uric a.	—	—
10	6	24 mos.	0 1 20	O. L.	O. L., Uts.	—	—	2 calculi.
	6	Ditto	0 0 50	Uts., O. L.	Ditto	Ditto	—	—
	7	12 mos.	0 5 16	Ūric, O. L.	Ditto	Uts., O. L.	—	—
	7	24 mos.	0 1 12	O. L.	O. L.	O. L.	—	2 calculi.
	7	12 mos.	0 4 30	Uts., O. L.	Ditto	Ūric, O. L.	—	—
15	7	Ditto	0 2 40	Uts., O. L.	Ditto	Uts., T. Ph.	—	—
	7	2 mos.	0 1 1	O. L.	Ditto, Ūric	Uric a.	Deccan	—
	7	36 mos.	0 2 1	Uts., O. L.	Ditto	Ditto	Sinde	—

MALE.—(*b*) *Vesical*—continued.

No.	Age.	Duration of symptoms.	Weight.	Nucleus.	Body.	Crust.	Locality.	Remarks.
	Year.		Oz. drs. gr.					
	8	24 mos.	0 1 0	O. L.	O. L.	Uric a.	Deccan	3 hempseed calculi.
	9	6 mos.	1 0 36	O. L.	Ditto	Tr. Ph.	—	—
20	10	—	0 2 16	Uts., O. L.	O. L.	Ditto	—	—
	5	—	0 4 35	Uric, mixed	Ditto	O. L.	Bhooj	—
	5	—	1 0 0	Uts., O. L.	Uric a.	Uric a.	—	—
	6	—	0 4 30	Uts., O. L.	O. L., Uts.	O. L., Ph.	—	—
	6	—	0 3 20	Uts., O. L.	Ditto, T. Ph.	O. L., T. Ph.	—	—
25	6	—	0 2 40	Uts., O. L.	Uric, Uts.	Uric, Uts.	—	—
	7	—	0 4 0	Uts., O. L.	Ditto	Uric a.	—	—
	8	—	0 6 0	O. L.	O. L., Ph.	O. L.	—	—
	8	—	0 3 0	O. L.	Uric a.	Uric a.	—	—
	9	—	0 3 30	O. L., mixed	O. L.	O. L.	—	—
30	9	—	0 5 50	Uric, mixed	Uric a.	Ditto	—	—
	9	—	0 5 6	Uts., O. L.	Uric, mixed	Uric a.	—	—
	10	—	1 4 20	Uts.	Ut., O. L., Pl.	U., Pl., T. Ph.	—	3 calculi.
	11	—	0 1 30	Uts., O. L.	Ditto	Uts., T. Ph.	Deccan	—
	14	5 years	1 3 0	Uts., O. L.	Ditto	Ditto	—	—
35	14	12 mos.	0 3 30	Uts., O. L.	Ditto	Ditto	Sinde	—
	14	8 years	1 4 40	Uts., O. L.	Ditto	Ditto	Deccan	—
	15	—	3 3 0	Uts., O. L.	O. L.	T. Ph.	—	2 calculi.
	16	3 years	0 6 0	Uts., O. L.	Ditto	O. L.	—	—
	17	—	1 5 30	O. L.	Uts., O. L.	Ditto	—	—
40	20	2½ years	0 7 26	Uric, O. L.	Ditto	O. L., T. Ph.	—	—
	20	—	0 1 16	Uts., O. L.	Ditto	O. L.	—	—
	11	—	0 6 30	O. L.	Uric, O. L.	Ditto	Bhooj	—
	11	—	0 4 24	Uts., O. L.	Ditto	Ditto	—	—
	15	—	0 2 30	Uts.	O. L.	Ditto	—	—
45	16	—	0 2 36	Uts.	Ditto	Ditto	—	—
	16	—	0 5 50	Uts., O. L.	Ditto	T. Ph.	—	—
	16	—	1 0 15	Uts., O. L.	Ditto	O. L.	—	—
	17	—	0 3 0	Uts., O. L.	Ditto	T. Ph.	Deccan	—
	26	4 years	2 0 40	O. L.	Uric, mixed	Ditto	Ditto	Renal calculi of uric acid.
50	26	5 years	4 2 20	O. L.	O. L.	Ditto	—	—
	26	10 years	0 6 26	O. L.	Ditto	Ditto	—	—
	27	1 year	1 1 30	Uts., O. L.	Uts., O. L.	O. L.	—	—
	24	—	1 3 0	Uts., Uric	O. L., Uric	O. L., T. Ph.	Bhooj	—
	30	—	1 3 0	O. L.	Ditto	Ditto	—	—
55	30	9 mos.	1 2 0	O. L.	Uts., O. L.	Uts., T. Ph.	Deccan	—
	32	—	1 0 40	Uric, mixed	Ditto, Uts.	T. Ph.	—	—
	32	3 years	0 3 28	O. L., Uts. ?	Uric a.	Uts., O. L.	—	—
	35	Ditto	1 0 0	O. L.	Ditto	Ditto	—	—
	35	—	Vy. large	O. L.	O. L.	T. Ph.	—	—
60	40	—	1 4 0	Hairs, F. C.	Fus. Cal.	Ditto	—	—
	31	—	1 4 20	Uts., O. L.	O. L.	O. L.	Bhooj	—
	35	—	0 2 24	Uric., O. L.	Uric a.	Uric a.	—	—
	51	—	2 0 24	O. L.	Uric, O. L.	Ditto	Deccan	—
	60	—	2 4 6	O. L.	Uric a.	Ditto	—	Renal calculi.

The ingredients microscopically distinguished in these calculi being the following—uric acid, the urates, oxalate of lime, phosphate of lime, triple phosphate, fusible calculus, besides extraneous or incidental matters—they may be arranged as below.

TABLE II.—*Structural elements of Urinary Calculi*

Order.	Genus.	Species.	Chemical composition.
Organic	Hæmatic	Red globules, fibrine, albumen ?	
	Secretory	Mucus, pus ? epithelium, colouring matter, indigo.	
	Vegetable	Fungi.	
	Extraneous	Hairs.	
Inorganic	(*a*) Granules	Coloured	Urates.
		Colourless	Phosphate of lime.
			Oxalate of lime ?
	(*b*) Globules or spheroids	Coloured	Urates
		Colourless	Oxalate of lime.
	(*c*) Glomerules or aggregated spheroids	Coloured	Urates.
		Colourless	Oxalate of lime.
	(*d*) Crystals	Coloured, acicular	Urates.
		rhomboid	Uric acid.
		Colourless, dumb-bell, octohedral, &c.	Oxalate of lime.
		prismatic	Triple phosphate.
	(*e*) Laminæ	Coloured, translucent	Uric acid.
			Oxalate of lime.
		opaque	Urates.
		Colourless, regular	Oxalate of lime.
		irregular	Triple phosphate.
			Phosphate of lime.

No attempt was made in this inquiry to detect new or rarer constituents of the urine in calculous matter; but, except violet colouring matters and blood-crystals, there was no reason to suspect their existence in the specimens examined.

URIC ACID

PLATE I

Is present under some form in 36 per cent. of vesical calculi, but forms the apparent nucleus in only about 10 per cent.; in order of deposit, it very seldom precedes, but not unfrequently follows, the urates; and a similar but much less marked relation is observed with respect to the oxalate of lime; in minute quantity, however, this latter salt is very common amongst calculous layers of uric acid, whilst the urates are very seldom indeed found to be intermixed.

The structural forms assumed by uric acid in calculi are of a wholly crystalline character, and their variety may bear a relation to the rapidity of deposit. They are—

1. *Separate Crystals* (figs. 1, 8).—Large and compact, apparently modifications of the rhomb or cube, and showing a tendency to become apposed. Collections of such crystals are seldom considerable, nor have there been noticed the varieties of form and size, or the clusters or compound crystals, so generally present in urinary deposits composed of uric acid. These crystals may be found in both primary and succeeding layers of calculi.

2. *Loose Columns* (figs. 2, 4, 5).—These are made up of large angular and elongated crystals, placed end to end or loosely blended, and thus forming open layers; sometimes they are built up, as it were, into series of arcades visible to the unassisted eye, and comparable in general appearance to the chambered walls of certain shells.

3. *Compact Laminæ* (figs. 3, 7, 10).—The most frequent form, usually well-defined, and often thin, close-set, parallel, and numerous. Such laminæ are also primarily composed of rhomboid crystals, which, being closely apposed, blend more or less completely, so that a concentric or radiate arrangement is seldom evident in the layers so formed, but rather the appearance of a uniform crystalline deposit. As a rare variety small, narrow, elongated crystals may be found arranged in compact rows (fig. 3).

When calculous laminæ of uric acid thus formed are dissolved by liquor potassæ, there will commonly be seen intermixed particles unaffected by the alkali (fig. 10). These are dumb-bell and other forms of oxalate of lime, and apparently they have no definite relation to the several laminæ, though such may exist. The oxalate is very frequently associated with uric acid deposits, and small renal calculi, seemingly wholly composed of the latter, may have the former as crystals at their nucleus (fig. 11) or as dumb-bells and spheroids; it is present in most parts, and in such calculi one or more pale, translucent layers may be

detected, which have a clear crystalline structure, probably referable to the oxalate (figs. 7 and 9). To the admixture of various ingredients, as well as to the different forms assumed by uric acid in calculous layers, may be attributed the diversity of structure which even small renal calculi display (figs. 6, 7). The urates, however, even in a granular form, are seldom found intermixed, and crystals of the triple phosphate were never seen. Phosphate of lime, as granules, may be present; in the crystallized form it has not here been verified.

Calculi formed of uric acid are not uncommonly coated by the triple phosphate, yet less often than are oxalate of lime calculi.

An *organic basis* is apparent when uric acid laminæ are treated with liquor potassæ, and in them it exists as a defined, homogeneous matrix, either transparent, very finely grnular, or slightly striated; it is not always abundant, and may not be found in the looser formations or in the free crystals of uric acid. Such matrix exhibits no sign of cell structure.

Artificial Cells or Globules (fig. 12).—During solution by potash of uric acid calculous deposits, after a time, is seen the production of dark brown, opaque granules, arising independently in the obviously denser liquid around the dissolving particles of uric acid, and these, after gradually assuming a larger size, defined wall, and compact granular nucleus, separated therefrom by a clear interval, slowly move away, lose their opacity, and fading, disappear as faint vesicles, leaving no trace behind. The entire process occupies only a few minutes.

These globules or cells may be seen to blend, but do not form a compact structure. Their nucleus first appears; it is sometimes striated, and it disappears with or before the delicate cell-wall. Along with these, much larger, clear vesicles are visible, or occasionally, in the neighbourhood, small, colourless, hexagonal plates, eventually assuming the appearance of such vesicles, may be detected, and commonly dense clusters of the urate of potash are formed, which sometimes come to resemble opaque globules fringed with fine spiculæ.

The spurious cells are present when uric acid is in excess; the delicate spiculæ when a perfect salt is produced, and the latter may be seen to succeed the former.

These artificial forms have so much similarity in appearance to the dark globules of urate of soda, &c., that it might be thought that the two structures are of the same nature; and instances do occur when, by the action of potash on the urates, a somewhat similar appearance is noticed in the surviving matrix. Besides, while indicating the mode in which ordinary globules of the urates may arise, the experiment described furnishes an illustration of the influence of attendant conditions in modifying the process of crystallization, so that sub-morphous forms are produced; that these were temporary in duration is obviously attributable to the circumstances of the experiment.

THE URATES

PLATE II

The urates are the most frequent of urinary deposits, and they oftenest form the chief part of the nucleus of urinary calculi, but they are not the most universal ingredient of the latter, for this place must be assigned to the oxalate of lime. The connection of the two classes of salts is, however, intimate, and in a state perfectly unmixed with oxalate the urates have never been found in calculous matter.

They exist in some form in 62 per cent. of vesical calculi, forming the mass of the nucleus in 56 per cent.; as a deposit they commonly precede, but rarely follow, the oxalate of lime; and sometimes they precede uric acid, very seldom indeed succeeding to it.

All forms of the urates known as urinary deposits occur in calculi, and there are some forms peculiar to the latter.

1. *Granules* (figs. 1 and 2).—Universally present, coarse rather than fine, bright coloured or brown, orange, or yellow, loosely compacted, commonly opaque in the mass, and of varying size. A fundamental form, and that in which others arise. Occasionally may be seen larger angular or rounded particles, which it is conjectured are an early form of the globules described below; and crystals of the oxalate of lime are very generally intermixed with these granules.

2. *Spiculæ*, or fine acicular crystals (fig. 3), are less frequent than, but coexist with, the granules; their size is minute, form delicate, pointed or prismatic; they are either free or in crossed clusters, or in radiating fascicles; commonly, they envelope the globules, with which they have probably an essential connection; this form, too, is primary.

Larger spiculæ are found, having a granular appearance, and being closely clustered together; and elongated filaments are occasionally seen, forming by their aggregation compact layers (figs. 9, 10). These latter forms may be derived from disintegrated globules and laminæ.

3. *Globules*, or spherical particles (figs. 4, 5, 6, 7).—Known as a urinary deposit, and a frequent element of urinary calculi, being sometimes found in immense numbers in both nuclei and subsequent layers. Their size, form, and colour vary; consistence firm; seen by transmitted light, they are dark, brightest in the centre, with a fine, granular aspect; in a dense medium, as Canada balsam, and on section a concentric structure becomes apparent; the nucleus is small, granular, and light coloured, or there may be a bright spot, like a nucleolus; the succeeding rings are often alternately dark and light, granular or clear. The outermost is defined, but a cell-wall does not exist. Indications of a radiate structure are also sometimes apparent. These globules arise in the

midst of the granules, and they grow by accretion. They possess a tendency to unite and blend, and it would seem that from this regular apposition and fusion the laminæ described below are produced.

On the addition of water the globules become slightly distended, and their internal structure is then better displayed; other reagents, rupture by pressure, and natural disintegration, also serve as means for disclosing their composite structure, the inner radiating arrangement becoming more evident.

A variety of the globules may be termed "flattened cells," from their apparent want of rotundity, and the character of the markings left in their matrix (fig. 8). They are to be seen in the central parts of calculi, but oftener in subsequent layers; their size is considerable, the nucleus large and granular, the concentric layers numerous and defined, being separated by bright intervals, and either granular or marked in a radiated manner. The attendant matrix is often coarse or striated, and the whole appearance rather like that of advancing disintegration; such large globules are sometimes found externally amongst layers of the triple phosphate.

Among numerous sub-varieties of these globules one is worthy of notice which was not cleared by potassic solution, but was rendered transparent by acetic acid; there were here indications of the presence of lime, either as phosphate or base of urate.

4. *Laminæ* (figs. 11, 12, 13, &c.).—Urates in this form are only found in calculi, laminæ being very common in both early and later deposits, to which they impart a compact and regular form; their colour is generally dark buff, or even brown, but it may be also of a much lighter tint, and their consistence is commonly firm.

Owing to the various stages of formation at which they are seen, the laminæ present different appearances; some are barely perceptible amongst the clustering globules (fig. 16), others fully formed, are defined, close set, and numerous, either very thin, disposed in parallel layers, differing only in tint, and of wholly granular aspect, or more commonly thick and compact; their course is often level, sometimes wavy or sinuous, and while a granular aspect predominates, occasionally there are distinct vertical or radiate markings, which are best seen in those laminæ apparently undergoing disintegration.

Imbedded in these laminæ, and hidden until revealed by the solvent action of potash, are frequently found crystals of the oxalate of lime; but these do not appear to hold any determinate relation to their course or character (fig. 13).

The ordinary formation of laminæ from the larger blended globules is often very apparent; the earliest layers are seen to be segments of circles, and those following to become less and less curved, until the layers are wavy or straight, parallelism being preserved. That laminæ

may gain in thickness by direct deposition of urates can only be supposed on the presumption that changes occur after such precipitation.

It would be superfluous to describe all the intermediate stages of transition from globules to straight laminæ, since the process is known to elsewhere occur under conditions similar to those probably existing in the urinary organs themselves, namely, when nascent salts assume the solid form in the presence of a viscid medium, and afterwards, for a time, the same conditions are maintained. The illustrations will serve to indicate some of these stages (*vide* Plate II).

A distinct *animal basis* is commonly left on solution of urate deposits by potash, and is especially distinct when appertaining to the globules and laminæ; the shape and concentric structure of the former and the lamellar arrangement of the latter being clearly impressed in a consistent, clear, or obscurely granular or fibrous matrix, or soft mass; and the action of acetic acid leads to the same result, but less favorably for observation. This basis of organic matter does not present further signs of organization than do the structures which it underlies; no cell-wall or limitary membrane is seen, yet the organic matrix is an essential part of these sub-morphous structures, and it is significant of the conditions under which they were produced.

Some observations were made upon the bases of the urates, but beyond the fact that sodium appeared commoner than was anticipated, the results need not be given in detail; the very small proportion in which the bases of the urates are present is worthy of notice.

OXALATE OF LIME

PLATE III

The comparative frequency of the oxalate of lime in calculi has no counterpart, so far as known, as regards ordinary deposits from the urine; and in this respect the salt differs from both uric acid and the urates.

It is the most common ingredient, occurring in 70 per cent. of these calculi, and it formed the nucleus of more than 35 per cent.; in order of deposit it may precede or follow uric acid; it rarely precedes the urates, but very often succeeds to them; more often than either does the oxalate induce precipitation of the triple phosphate.

Oxalate of lime, like the urates, appears in forms, some of which are identical with those seen in urine, whilst others are peculiar to calculous deposits.

1. *Granules* (fig. 1).—Such were amorphous particles unaffected by ordinary reagents, and found in closest proximity to crystals of the oxalate. As only a moderate magnifying power was available, it is not certain that these granules were not minute crystals.

2. *Crystals* imbedded commonly in the urates.—*The octohedron* is not very uncommon; it occurs in calculi of all sizes, and of varied composition, and it is found in the nuclei, in layers following, and on the surface. This very characteristic form is remarkable for the wide variation in size which it exhibits, even in the same deposit, and, besides, there are numerous modifications observed of shape, combination, &c.; thus, enormous crystals having the pointed character of octohedra may be found in the central parts, where they have been seen arranged in a radiating manner, and partially blended; peculiar markings were also detected, with other features shown in Plate IV, fig. 3; on the surface of calculi the large pointed crystals either project or are inclined, sometimes in fascicles, not unlike willow-leaves in shape.

The *rounded, ovoid,* and *dumb-bell* forms are more frequent and more widely diffused than the above; few calculi in size above the smallest are free from them, the only exceptions being phosphatic calculi, in which, however, octohedra are not very unusual. The dumb-bell and allied forms seem to be especially associated with uric acid laminæ and layers of the urates, both of which seldom fail to reveal their presence on dissolution; they are also found in collections of the spheroids, to which they bear an essential relation.

The simplest form is a minute, clear, rounded, or oval crystal; a nucleus, apparent or real, may sometimes be seen; clusters of such crystals occur.

The true dumb-bell shape may arise from the blending of two such crystals, but this stage is not frequently seen; the size varies considerably, and the form is more or less decided; transition from the dumb-bell to globular form is often noticed; for dumb-bells have a tendency to cluster together, and the mass thus formed, while undergoing a remodelling, as it were, by reposition of the particles composing its structural elements, may also be enlarged by addition to the surface, the final result being one of the bodies here termed "spheroids."

Dumb-bells, when of large size, sometimes exhibit marks of apparent disintegration in the converging lines, by which each half is partially cleft into clusters of columns or fibres (*vide* Plate III).

3. *Spheroids* or *globules* (figs. 4, 5, 8, &c.).—A very characteristic form, rarely seen in the urine. When of small size many may be found intermixed with columnar or laminated uric acid, and with layers of the urates; when of large size, spheroidal particles with their *débris* may wholly compose the pale, loose, gritty deposits of oxalate of lime which are sometimes found in calculi. Their size varies much, some spheroids

attaining large dimensions; they are devoid of colour, except when stained with blood; they are highly refractile, and may show a dark or light cross; in shape they are spherical or ovoid, or, when blended, tuberose; the surface, when whole, may be smooth. On section, or when placed in Canada balsam, they exhibit a nucleus which is sometimes of dark brown colour (resembling urates), of round or oval or dumb-bell shape, and of measurable dimensions; this nucleus seems to disappear after a while. A striking feature is the numerous delicate markings indicative of both radiate and concentric structure, which many spheroids exhibit; more often, however, other lines are seen without and within, which are indicative of structure, and probably at the same time of disintegration; and hence it would appear that the spheroids are composed of small flat fibres or columns, not seldom arranged in a somewhat similar manner to the fibres of the crystalline lens, only crossing each other in numerous planes and less regularly disposed. This appearance is owing to the edges of apposed scales or lamellæ, of which the spheroid is seemingly built up, becoming visible; the scales have also a tendency to become detached, and the real construction of the spheroids then becomes evident; such free scales resemble crystals, and when collected together they impart an appearance not unlike that of vegetable cellular tissue. Several varieties of construction might be described, of which some are displayed in the figures.

Not only do separate spheroids thus break up into segments, but rows of them may so change as to lead to the appearance of continuous layers of radiating columns or clustered crystals, and in a similar manner compact laminæ (orginally formed from spheroids), by disintegration, come to show radiating and transverse markings.

The changes here attributed to disintegration probably take place soon after deposit or formation of the spheroids, and they may be explained by succeeding alterations in the density and other characters of the circumambient urine.

It would appear that these characteristic spheroidal bodies originate in clustering and blending of the dumb-bell crystals, attended with deposition on the surface of the aggregated particles. They were often large, and seemingly coarse, when associated with blood-masses.

4. *Laminæ.*—A characteristic and common form, in which oxalate of lime appears in urinary calculi, and, as is the case with the urates, these layers probably often arise from a previous spheroidal or globular condition of the salt. It has occasionally appeared as if spheroids passing into laminæ had commenced upon a nucleus of the urates. Incipient laminæ are seen to present an arched and wavy course, corresponding to the contour of subjacent or inclosed spheroids, by accretion to the surface of which thick layers are eventually produced, still retaining marks of both radiating and concentric structure. And herein, it may be re-

marked, appears an explanation of the general tubercular character of oxalate deposits. Such laminæ are often very compact, and as beautifully marked with parallel lines as certain kinds of hard shell. They may attain to considerable thickness, and of them small calculi may be wholly formed, the nuclei being a spheroidal mass. Their ordinary appearance is very different to laminæ of both uric acid and the urates, owing to their greater hardness, darker colour, and compactness, and, when minutely examined, a curious, though superficial, resemblance to the lacunæ and canaliculi of compact osseous tissue is sometimes noticed. The general features of these hard, dark, laminar deposits are sufficiently known. They may alternate with every other variety, and are particularly striking when observed in the midst of the triple or mixed phosphates.

A tendency to break up, commonly in direction of their radii, sometimes transversely along the concentric lines, is probably indicative of incipient disintegration, and, at a further stage, column-like clusters may result.

Animal Basis of Oxalate Forms.—It is well known that dumb-bell crystals and their agglomerations possess a distinct matrix of organic matter, which becomes visible when the mineral constituents are removed by weak acids. No special characters can be attributed to this matrix, nor does it present marks of cell-formation.

Crystals of Oxalate of Lime artificially produced.—On the addition of oxalate of ammonia to slides containing both oxalate forms, and probably granules of the phosphate of lime, subjected to the prolonged action of acetic acid or potassic solution, may be observed the production of fresh crystals of oxalate of lime in several minute forms, the most noteworthy of which are star-like in shape, and, excepting in size, comparable to the radiate disposition of octohedral crystals sometimes noticed in calculous matter. Transition from the rounded or oval form into dumb-bell and octohedral may also be observed, under certain circumstances. The experiment is an instructive one.

PECULIAR CRYSTALS

PLATE IV

Constantly intermixed with urates in the interior of calculi are found numerous clear, colourless, crystalline particles, not referable to any known form of urinary deposit, and the same crystals may be detected in calculi composed of uric acid or oxalate of lime. Usually, they have the shape of rhomboid plates, varying in thickness, or of rhombic prisms,

and their modifications (*vide* fig. 1), and they are found either in scattered groups or disposed in one or more layers.

These crystals are unaffected by acetic acid, solution of potash, or oxalate of ammonia; they are quickly dissolved by nitric acid, and on one occasion were distinctly observed to become opaque by heat, and then to dissolve with effervescence in acetic acid—a test which in conjunction with those before mentioned would prove them to be composed of oxalate of lime. It is, indeed, in close juxtaposition with admitted forms of this salt that the crystals in question most abound, and appearances are such as to favour the supposition of their being derived from either spheroids or octohedra, by a process of disintegration and subsequent remodelling of the separated particles. Their resemblance to the scales so often found together with spheroids of the oxalate is sometimes remarkable, only these want the sharp angles and straight sides of the crystals, and the radiate disposition sometimes assumed by the crystals seems best explicable on the supposition of their origin from disintegrating spheroids. The figures in Plates III and IV sufficiently illustrate these remarks; see especially fig. 10, Plate III, where is delineated the nucleus of a hemp-seed calculus, and fig. 5, Plate IV, showing the structure of certain translucent layers noticed in the same calculus; it is also presumed that the clear crystalline layer having the appearance figured in Plate I, fig, 9, was of similar character.

Calculous layers in which these crystals abound do sometimes present the general character ascribed to phosphate of lime deposits, being pale, compact, brittle, and liable to become detached in thin laminæ, but in their case chemical tests have indicated the presence of the oxalate, and other microscopic forms of this salt may also be found in conjunction. When, too, the presence of phosphoric acid was indicated, commonly the triple phosphate was intermixed, and when either absent or present, granular matter resembling amorphous phosphate of lime was there, so that an evident source of the phosphoric acid was apparent.

So far as is known, the only other salt to which these crystals could be referred is the phosphate of lime, and to that variety delineated in Plate IV, fig. 7*a*, but here the resemblance is a general one, and would require that the separated plates in the columns were detached, which they never were observed to be; and further, the solvent action of acetic acid in the phosphate was clear, while this reagent does not affect the peculiar crystals.

Hence, it is concluded that in urinary calculi the oxalate of lime is present, alone or mixed with urates, &c., under a form not hitherto recognised, viz. as free crystals of large size and characteristic shape, and that this form may be the result of changes in the better known octohedra, spheroids, or probably even the laminæ composed of this salt, these changes being the disintegration and subsequent remodelling of de-

tached fragments, such as are known to occur amongst artificially produced calculi of the carbonate of lime under altered physical conditions; but that the free crystals now described may more directly arise, in some instances, cannot be denied, seeing that amongst both plants and minerals, as well as in parts of the animal frame, the oxalate of lime is found in a prismatic form, and there being certain examples amongst the two former kingdoms in which the prisms resemble these free crystals.

The crystals here styled "peculiar" will be again referred to in the second part of this memoir.

PHOSPHATE OF LIME

PLATE IV

This salt occurs as a urinary deposit in the granular state most frequently; crystals of lime phosphate are, however, found occasionally, or, according to some interpretations, not uncommonly, but none of the forms described are seen to occur in urinary calculi, nor are the fine crystals, which may be artificially produced, represented in these concretions, free crystals of the phosphate not having been detected in them.

It is authoritatively stated, on chemical evidence, that while never forming the nucleus, or the whole, of a urinary calculus, phosphate of lime is very common as a principal constituent, and that in small amount it is found in nearly all calculi.

As an opaque, granular, or amorphous deposit, it may, indeed, be frequent, for on the addition of liquor potassa to the granular urates, and after their solution, some amorphous matter commonly remains unacted on, which may be phosphate of lime, but at present no peculiar microscopic characters can be attributed to this form. In such state the salt exists amongst prostatic calculi, prisms of the triple phosphate being sometimes intermingled.

As a compact crystalline deposit, the phosphate is by no means common; the clear structure then shows concentric laminar markings, but yet more defined radiating lines, along which fracture so readily occurs that a fibrous appearance is sometimes imparted when such deposit forms the crust of a calculus. The microscopic characters of the deposit is shown in Plate IV, fig. 7, where the more uniform layers are seen to be made up of long prisms, or columns of more than three sides, and marked with parallel cross-lines, which clearly show, in some cases

a laminar composition. These laminæ or plates were never found detached, although their separate existence was indicated during the solvent action of acetic acid. Generally the tendency of the columns is to separate longitudinally, and to break up into irregular, thin lamellæ, by the apposition of which they then appear to be composed. Granular layers are interposed between the columns.

The more friable or fibrous crystalline layers, are seen to be made up of numerous and less regular plates, presenting no transverse markings, and loosely connected; occasionally they show a radiate or converging tendency, and during the action of acetic acid the crystalline material is observed to be arranged in narrow detached rows. The whole appearance of this form appears to indicate disintegration of a preceding, more compact state.

The *animal basis*, or matrix, of these deposits, as seen after the action of acetic acid, is unusually abundant and defined, and it often retains much of the appearance of the entire crystals.

It is stated that the phosphate of lime in this crystallized state readily fuses before the blowpipe, and contains a larger proportion of phosphoric acid than the granular form, which is infusible. Acetic acid soon dissolves the crystals, not, however, acting so quickly as on the prisms of the triple phosphate. But a variation exists in this respect, and a form of prism, or column, may be found presenting microscopic characters intermediate, as it were, to those of the two phosphatic salts. Doubtless, the distinctive features of the crystalline layers, composed respectively of phosphate of lime and of triple phosphate, are marked, but an impression has arisen, in the course of the present inquiry, that the latter is the fundamental or more characteristic form, and that it is likely transitional states do exist, passing thence to the rarer variety of lime phosphate, but what may be the real composition of such intermediate forms has not yet been ascertained.

Since in my collections of Indian calculi were no specimens of pure crystalline phosphate of lime deposits, recourse to other examples was inevitable, and from them the above description is derived.* On other occasions, when, from ordinary appearances, it was supposed that phosphate of lime would be found in certain layers of calculi, modified crystals of the oxalate, alone or combined with crystals of the triple phosphate, and always mixed with much granular matter, were discovered to prevail.

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* I am indebted to Professor Flower, Conservator of the Hunterian Museum, for courteous and most ready assistance in procuring specimens.

TRIPLE PHOSPHATE

PLATE IV

Regarding deposits of this salt, as produced locally in the urinary tracts, and contingently on mechanical exciting causes, a more limited interest attaches to them.

By means of the microscope crystals of the triple phosphate may be found very near the nucleus of a calculus, as well as in successive layers, when, by the unaided eye, the usual appearances of this phosphatic deposit are not to be detected.

In urinary calculi prisms of the well-known character, single or combined, are the only forms yet noticed; stellæ, &c., of the triple phosphate, were never seen.

Generally, in defined layers, the prisms are undistinguishable, from their being closely blended. The resulting masses have, however, a characteristic appearance comparable to that of frozen snow, and their markings are peculiar. In accidental cavities, or the looser formations, or on the exterior of calculi, the prisms may be found more or less detached, but, though often large, especially in the last-named position, they are seldom quite perfect.

Acetic acid, after the briefest delay, dissolves deposits of this salt almost as rapidly as a flying shadow passes; bubbles of gas are evolved, and a well-defined matrix is left, which may not be a mere shell.

Urates and small octohedra of oxalate of lime are not uncommonly found associated with the salt, and some other granular matter is generally present.

Deposits of the triple phosphate may be succeeded by oxalate of lime, or even by uric acid.

FUSIBLE SALT

PLATE IV

The more prominent microscopic characters of the fusible calculus are those of the triple phosphate, which largely enters into its composition.

The prisms were once noticed to present an appearance of breaking up into smaller segments, and at the same time laminæ or thin plates and granular crystalline masses were observed; they were not unlike in

aspect to the crystallized form of lime phosphate, yet differed in being much more amenable than it to the solvent action of acetic acid.

Commonly, the admixed phosphate of lime is in a granular or amorphous state.

Summary of the preceding observations

1. It is evident that urinary calculi are not mere precipitates or aggregations of ordinary crystalline and amorphous deposits, held together by means of mucus, &c. I hardly know what may be the prevalent notions on this subject, but venture to remark that simple inspection of the structure of many calculi, as exhibited in sections, might have elicited an opinion that these bodies, from their compactness and regularity of construction, cannot be mere accretions; they are, too, unlike the products of calcareous degeneration, and their complexity and freedom from angular shapes are features inconsistent with crystalline formation. Some specimens, indeed, display a special beauty of varied arrangement, which I think is not sufficiently recognised, but which alone might have led to the suspicion that association with a living organism must be needful for their production; so commonly, however, are calculi relegated to the chemical laboratory, that their structural composition has hitherto been but little noticed.

2. Another feature made prominent by microscopic examination is the presence of an animal basis as an essential component of urinary calculi. It has been observed that both crystalline and sub-morphous ingredients possess a substratum, evident on removal of the mineral parts, which is of firm consistence, more or less translucent, colourless, structureless, and obviously

of organic origin; such material underlies the compact layers of uric acid and the more brittle ones of both kinds of phosphates, as well as all urate formations beyond the granular, and some of those of the calcic oxalate. Nowhere, however, has this animal matter been found to exist alone, as a separate ingredient of calculi. Judging from appearances, it is probably not always identically the same; its fullest development seems to attend urate globules and laminæ whose structure is exactly retained in their organic basis, until destroyed by the continued action of reagents; and the only approach to organization which it presents has been a finely granular, striated, or fibrillated appearance.

3. The main result, however, of my inquiries, is the fact that some of the more characteristic ingredients of urinary calculi are present in forms peculiar to a group of structures which, though immediately of physical origin, yet seem to hold a position intermediate between the pure mineral and the organic. For such structures I would propose the name "*sub-morphous*," in contradistinction to the a-morphous, so called; separately, they have in this memoir been termed "globules," "dumb-bells," "spheroids," "laminæ," &c., but it may be convenient to possess a common term for them and the like. Since bodies belonging to the group of sub-morphisms can be synthetically produced by experiment, it is evident that some light may hence be derived as to the conditions and manner regulating the formation of calculi within the body, and this subject will be considered in the second part of the present Essay.

4. Special attention having been given to the discri-

mination, so far as is possible, of the nuclei or first-formed ingredients of calculi, it is now ascertained that very frequently does the commencement of a stone seem to be due to accumulation or unusual formation of the globular urates; that not seldom is the oxalate in sub-morphous form the first material laid down, and that comparatively seldom do crystals of uric acid compose the nucleus of a calculus. This subject will be again reverted to at the close; and now it need only be said that, evidently, a mere aggregation of ordinary urinary deposits does not suffice to account for the appearance, any more than for the growth, of a stone. Since in all calculi of spontaneous origin the nucleus was found to be solid, and not composed of inspissated mucus, &c., the opinion that stone is often the result of accident is not, independently of other considerations, sustained by these researches.

PART II

MODE OF FORMATION OF CALCULI

It has been advanced as one result of the present inquiry that, not by a rough mechanism, such as precipitation and an agglutinising process, can be understood the frequently elaborate and peculiar structure of a "stone." It was therefore necessary to search for other explanation, and such has been found. Previously, however, to describing the process of "molecular coalescence," it may be as well to mention some comparative facts concerning substances more or less cognate, it might be supposed, with urinary calculi, and the occasion will also serve for reference to the question of cell-influence in the formation of the latter.

Amongst plants it is not rare to find *Raphides* or spicular and other-shaped crystals within the vegetable cell, the salts of which they are composed being commonly the same as some found in the urinary secretion, namely, the oxalate and phosphate of lime. As compared with those occurring in mineral substances, the forms of these crystals may be peculiar, yet there is no evidence of cell-action to the exclusion of such modifying influences as contact with colloid protoplasm or dialysing membrane like that of the cell-wall; and, in fact, raphidic crystals may be artificially produced in

cellular tissue long removed from connection with the living plant; as an exceptional instance (in a species of *Cactus*) the crystalline mass may possess an organic basis, yet this occurrence, while of interest, is explicable on physical principles. *Agates* are generally regarded as arising in combination with sponge-organisms, and in them I have noticed a structure to some extent parallel to that of oxalate of lime calculi, although their mineral ingredient is wholly different; the only sign noticed of possible cell-influence was the presence of coloured, rounded bodies, which were seen to blend with adjoining laminæ; these were probably spores, and as their occurrence was only very partial in the agate-mass, their influence upon the construction of the latter was not apparent, and even if real is not necessarily of a vital character. With regard to some *shell-structures*, it will be sufficient to remark that compact, and even incipient layers, often bear such a close resemblance to the product of experiment, that it is affirmed the intervention of cell-influence is not needed to account for their formation (Rainey and Harting); and some of these layers being very similar in character to those found in urinary calculi, the inference is again in favour of the latter originating in a manner essentially identical. Analogical evidence of this kind tends, therefore, to support the view of the non-vital origin of the sub-morphous structures named, notwithstanding their association with living organisms, or with matter once part of such.*

* The opinions of so able and practised an histologist as the late lamented Professor Quekett demand the fullest consideration, and had I been able to detect any satisfactory signs of cell-structure in the matrix of calculi it would have been a source of gratification to confirm the

That the structure of the animal "cell," like that of plants, is favorable to the production of crystalline and sub-morphous forms may be admitted on the ground of facts such as the following:—Gouty deposits of sodium urate in articular cartilage appear first in the cartilage-cells themselves, which serve as foci of deposit; and by direct experiment it is found that "sclerites" (spicular structures) of calcium carbonate and phosphate first appear in the cartilage-cells, afterwards extending into the surrounding intercellular substance (Harting). Here, therefore, are instances precisely corresponding to those above stated concerning Raphides, and no further remark is needed beyond the obvious one, that a third physical factor has to be taken into account, namely, that of a dialysing membrane (cell-wall), in addition to the two saline solutions and a colloid medium; of vital action, so called, there can be no necessity, since nature and experiment concur in one common result.

The question of the mode of construction of calculi must be kept apart from that of the origin of the materials needed for such construction; and it is not here proposed to discuss the latter subject, namely, when and how uric and oxalic acids and ammonia are pro-

views set forth in the 'Medical Times,' old series, vol. xxiv, 1851, p. 552. It has, however, been otherwise, and were these views more tenable than they appear, still one is bound to adopt a simpler explanation when that is at least equally convincing; really the latter is alone satisfactory. I would add to this note that, in the admirable 'Catalogue of Calculi' belonging to the Hunterian Museum, vol. ii, Preface, Mr Taylor has described, with some detail, the structure of the animal basis of urinary calculi, remarking that its constant presence and uniform distribution would render it probable that it is an *essential* constituent. It is one of the results of my microscopic researches to make certain this probability.

duced, or whence are derived phosphoric acid, lime, magnesia, &c. Let it only be admitted, as it may be consistently with received views, that these acids and bases are liberated, and combine, as they exist in the urine (probably by way of double decomposition), at some part of the urinary tract from glandular tubes onward, and the admission suffices, with collateral data, for elucidation of the first of the two questions just mentioned, which alone is in this place under consideration.

I must now advert to the work of others for a description of the process (termed by Mr Rainey "molecular coalescence"), which seems to underlie various phenomena of synthetic morphology; it is not here intended to connect this term with any theory, but simply to point out how sufficiently the process of molecular coalescence accounts for certain structures (and these very characteristic) which are found in urinary calculi, precisely as it accounts for parallel structures happening naturally, and capable of being reproduced in experiment. The conditions of experiment, I may add, are found to rule the results so completely that there seems reason to hope our conception of the circumstances under which calculous material is formed may in due course become far clearer than at present. The rudiments of the subject are here alone attempted, and recourse should unfailingly be had to original writings.

General phenomena of molecular coalescence; influence of colloid media upon crystalline forms.

1. *Molecular coalescence.*—When two saline solutions which are calculated to produce, by double decomposition, an insoluble carbonate of lime, are allowed to gradually and slowly intermix through the intervention of a viscous medium (such as dissolved gum or albumen), there are formed by the union of nascent salt with colloid, not crystals of the carbonate, but small, firm, rounded bodies, which are possessed of a concentric and radiate structure; and which, while disposed to adhere to any surface already existing (of itself capable of modifying their shape), commonly remain free as formed, but also exhibit a tendency to meet and blend together so as to lead to the construction of a laminar series. Such sub-morphous bodies composed of calcium carbonate have been seen, though rarely, in human urine, and they normally abound in the urine of the horse. Their resemblance to globules of the urates so well known to occur, at times, in human urine, is considerable enough to have already excited remark; and on carefully comparing them with the same urate forms as they are present in calculous matter, a decided similarity in general features will be apparent; such differences as appear, being doubtless owing to the varying nature of the saline ingredients, and to other attendant circumstances.

Some of the conditions influencing the process of molecular coalescence, in the instance quoted, are the following:—Should the solutions be dense, globules form slowly; and should they be of less specific gravity,

these may form in a few hours; if the saline solutions and colloid are at once mixed together, the globular and dumb-bell forms which appear are small, of uniform size, and stationary; if admixture be effected slowly and gradually, the globules are more perfect, and continue to grow for months; in a dense colloid the globules are fully rounded, in an attenuated medium there is a tendency to the production of crystals, and a gradational series of forms from crystalline to sub-morphous may appear in accordance with a corresponding change in the character of the colloid. How obviously such conditions as these are likely to be, at times, imitated in the urinary secretion of man, and with like results, will be apparent to all who admit that the present observations have any analogical force whatever.

Already a few carbonates, as those of baryta and strontia, are known to similarly form like globules; but others, as the carbonate of magnesia, do not (Rainey); nor will the calcium or triple phosphates, of themselves, thus assume the sub-morphous form; but they can, in small quantities, enter into combination with the lime carbonate, the result being the production of globules possessing special properties; and this circumstance is, I consider, of interest with reference to some of the larger "spheroids" described in my researches.

Mr Rainey has made known observations on the dissipation of the sub-morphous globules composed of lime carbonate, which claim notice in this place because of the light they throw upon the possible disintegration of calculi within the bladder, &c.; thus, if formed globules are submitted to the action of a solution denser than that in which they were produced, they gradually

disappear by erosion, commencing at the circumference; others produced under conditions favoring the combination of little salt with much colloid, are so unstable as to spontaneously disappear when conditions of place alone are changed; again, perfect globules merely exposed to a fresh solution, similar to that in which they were formed, may yet become disintegrated, this slight disturbance of conditions being sufficient; they become granular, show laminæ separated by dark amorphous lines, or become flattened, filled with air, &c., and finally disappear. Here, too, I cannot but notice how often the urate globules from calculi were seen by me presenting essentially the appearances just described, and how readily these last are explained, if it be admitted that changes in the quantity and quality of the urine, may operate upon formed globules, like as changes (not dissimilar in character) in the containing solutions mentioned above, are shown to affect the artificial product. These observations apply to only one given method of experiment, but it must be remembered that the nature of the colloid is at least as influential as other conditions, just as various dialysing membranes have different properties with respect to the solutions which they separate and connect.

Calcium oxalate does not unite with a gum colloid as does the corresponding carbonate; but Dr Ord has shown that, when produced in a medium of gelatine, it may appear in dumb-bell forms comparable to those seen in urine, and that, too, simultaneously with the crystals to be presently mentioned—a circumstance well worthy of note, because the same conjunction had been clearly made out with respect to deposits of the lime oxalate in urinary calculi (see Plates III and IV).

2. *Influence of colloids upon form of crystals.*—After much consideration I decided, for reasons stated, that the peculiar crystals described in Part I of this memoir (p. 22) were composed of oxalate of lime; now, crystals identical, to all appearance, with these may be artificially produced from calcium oxalate in a colloid of gelatine; so remarkably, indeed, do my figures correspond to those given by Dr Ord, that it seems almost needless to insist upon the identity of the crystalline forms referred to; yet, should this be allowed, there follows the great probability that it was under conditions not less alike in character, that both forms arose. Had these rhomboid plates alone been in question, the argument in favour of identity would have been a forcible one, but when it appears (see the figures) that several collateral forms also closely correspond, I confess but little doubt remains in my own mind that phenomenon and explanation here stand side by side. It is true that, judging from microscopic appearances, I have attributed the origin of certain fascicles of crystals* to partial disintegration of the larger spheroids, and subsequent remodelling, but this view does not necessarily clash with opinions based upon experiment.

With respect to crystals of uric acid, I find them in calculi to be so different in character to those noticed in urinary deposits that but one inference remains, and it also is confirmed by experiment; it is this, the crystals

* Bundles of crystals ("wheatsheaves"), comparable in shape to these, are found in the urine of the horse, in conjunction with the sub-morphous globules of calcium carbonate; and as it is inferred that in this animal the turbid urine acts as a sufficient colloid, the concurrence of these various crystalloid forms is noteworthy.

in question are modified in form and size from their being deposited in the presence of a colloid medium; it has been shown that even uric acid ingredients of calculi possess an animal basis, and hence the change of crystalline character. The same remark applies to the crystalline laminæ of calcium phosphate, and as well to those of the triple phosphate, as observed in urinary calculi. How far the characters of ordinary urinary deposits are influenced by similar conditions might well be further inquired into.

Finally, it should be observed, that the play of circumstances is of the most sensitive in instances of the kind under notice, so that if a reasonable similarity (this word and the like must be used, even if loosely) obtain between results which, necessarily, cannot proceed from identical conditions—natural and artificial surroundings being so different—such resemblance should, provisionally at least, be regarded as of valid weight.

I look forward to the time when experiments are made the conditions of which shall, more nearly than at present, approach those obtaining in the human body, as regards both saline principles and colloid medium; but until then oblique illumination (as it were) of the subject in question must stand in place of direct, and all that is here contended for is that light does appear.

General considerations on the occurrence and formation of Calculi, based upon the foregoing data.

Seeing the comparative infrequency of stone, it is apparent that only under certain circumstances do the more insoluble ingredients of the urine assume, or rather retain, the forms in which calculi arise, and by which they increase; hence it is that observed facts bearing directly on this subject are as yet so few, and in this dearth of positive knowledge any remarks I may offer will have more or less influence, according as they appear rational or only vague. Regarding, first, the probabilities of the case, it seems to me that the necessary conditions for the operation of molecular coalescence may at times well occur in the living human subject; thus, an excess of mucus, perhaps altered in character, in the urinary passages, or the effusion of albumen, fibrine or blood and the like, say from congestion of the kidneys or from irritation of the urinary tract, would furnish a colloid medium* with which uric acid, the urates or oxalates, themselves perhaps in excess, could combine in the manner before described; did there happen, also, an undue concentration or special loading of the urine, and the probabilities are strengthened that to some illness—fevers of various kinds, ague or an attack of cholera, renal congestion or inflammation—is

* Since the above was penned I find that Rindfleisch (vol. ii, p. 143), when treating of fibrinous casts in the urine, observes—"I have long been in favour of the view that the epithelial cells with which the straight tubes are lined generate a colloid material in their protoplasm which they pour out into the interior of the tubes." This remark seems to me of application beyond the special instance. Is not every degree of blood-pressure attended with such effusion?

correctly to be dated the commencement of a calculus. It must also be assumed that the continued growth of a stone is dependent upon the presence of organic matter, and this at every stage. I have noticed in the interstices of a nucleus composed of oxalate of lime spheroids and blood, isolated collections of rhomb-crystals such, as experiment shows, will appear in a firm colloid in which oxalic acid and lime are caused to meet, and I venture to suppose that in this case a small mass of mucus served as the medium; hence are to be explained—*i. e.* by varying local conditions—many peculiarities observed in the course of my researches; and it may be advanced that calculi in the kidneys, or bladder, are habitually surrounded by a thin layer of mucus (protective, therefore, only in a certain sense), in which goes on the process of molecular coalescence, resulting in the addition of fresh layers. To meet an objection, I would add, that it is extremely difficult to ascertain the chemical character of the animal basis of urinary calculi; but judging from the action of re-agents, it is probably albuminous, and "mucin" itself is classed amongst the derived albumens. Harting has found in experiment that albumen undergoes a change into what he terms "calco-globuline," a substance having reactions like those of chitine.

In the second place, from analogy is derived strong support in advocacy of the views now proposed; for it need hardly be repeated how close is the resemblance between some natural and artificial sub-morphous structures, and hence how forcible the inference that both arise under similar conditions.

In most experiments, it may here be observed, the influence of temperature has not been taken into

account, but Dr Ord has shown that, as compared with a less degree of heat, a temperature of 55°—65° F. greatly favours the production, in a colloid, of coalescence forms of the calcium oxalate; the temperature of the body being considerably higher than this, one may infer, I think, that it tends to promote still more the formation of sub-morphous structures.

Concluding suggestions and remarks.

As to the *diagnosis* of calculi, from what has now been advanced the necessity appears of giving increased attention to the characters of the urine, and to the forms assumed by urinary deposits. I do not hesitate to express my opinion, that several striking, and as yet obscure, crystalline bodies occasionally seen in the urine, will be found to correspond to those already, or hereafter to be, discriminated as entering into the construction of calculi, and that hence may arise valuable aid to diagnosis. The variety of sub-morphous and crystalline bodies which exist in calculous matter, is very considerable indeed; perhaps the more characteristic have been mentioned in this memoir, yet the subject claims far more extended notice than my condensed remarks can furnish. Doubtless simple changes in chemical composition may entail variety of shape, &c., but there is no evidence, so far as I know, that such changes are nearly so effective in producing almost numberless different forms, as are the slight variations of physical conditions inevitably attendant on the circumstances under which ordinarily proceeds the operation of molecular coa-

lescence. It is true that the structural elements of stone which I have described may not, as an accident, appear in the urine until the calculus is already partly formed, yet under any circumstances their possible diagnostic value will be gladly recognised.

With respect to the state of the urine itself, this will have to be regarded in a new light and with fresh interest; the direction of inquiry is sufficiently obvious.

I would invite attention to the results of my observations on the nature of the nucleus of urinary calculi, since if it be established that these concretions have frequently for their first-formed centre, a collection of urates, partly granular, spicular, and globular, many profitable inferences ensue, as regards diagnosis, prevention, and direct treatment. Any other deposit, I find, may follow the urates; commonly the calcic oxalate is intermixed with them, and this, too, is a circumstance to be borne in mind when examining the urine of children (*e. g.*) suffering from illness. The frequent presence of dumb-bell crystals of oxalate in urine would, in my opinion, be an indication of the possibility of a calculus being formed; especially, let it be added, when coarse uric acid gravel abounds at the same time. Unusual forms of uric acid deposits should be noticed, with reference to accompanying states of the urine. It is through associated, perhaps through consequent, conditions, that mere excess of insoluble saline ingredients can be conceived of as giving rise to stone.

Not rarely is a small quantity of blood found in the very centre of a stone, but since it is then almost always coexistent with oxalate of lime crystals or spheroids, the question arises whether or not it has

followed their production; the concurrence, however, of such crystals and blood in the urine, though in small amount, would be significant. Again, when the urine is clouded with mucus, attention should be paid to the character of the saline deposits; I have before remarked on the possible existence of other colloids in the urine.

That calculi are an accidental production one cannot credit; nor need it be held, on the views here set forth, that they are wholly due to bare physical causes. It may, however, be asked, if such seemingly intangible influences as an hereditary tendency to stone, and the well-known endemic character of the calculous disease, are not capable of being resolved into material conditions, *e. g.* the first-named into defect of structural development, and the latter into local states of climate or food; are not the two often associated?

Respecting, then, the origin of stone, I think it should be sought in a concurrence of circumstances, which may prove capable of early detection when a due acquaintance with its characters and signs is obtained; that it will eventually appear as a conjunction favorable to the occurrence of molecular coalescence in the ingredients of the urine, may be confidently surmised.

As to the growth of a stone, present knowledge indicates that (exceptions, as of the phosphates, apart) it proceeds but slowly; and experiments, too, have demonstrated that for the production of sub-morphous forms resembling those found in calculi, not only is time needed, but a persistence for weeks or months of tranquil and uniform conditions. There is no difficulty, I conceive, in supposing these conditions to sometimes exist in kidney or bladder; and such variations as are

found in calculous material are very readily explicable by their disturbance, or the substitution of other states, as might well happen in the body. Growth by accretion, or the direct addition of crystals and granules to pre-existing layers, undoubtedly occurs in calculi; but not without modification, in that an organic basis becomes inseparably blended with both crystals and granules, and hence the former assume a peculiar arrangement, and the latter undergo, often at least, a subsequent remodelling of their disposition.

Not to insist longer on these topics, I would conclude by observing, that those who have considered in detail the phenomena of molecular coalescence, and have become acquainted with the minute structure of urinary calculi found in man, can best grasp the subject of the origin and growth of stone.

The dispersion of calculi.—Seeing that calculous matter is not a mere cemented aggregation of crystals or granules, one can readily understand that the action of such solvents as may be safely introduced into the bladder is not so marked as might be anticipated. A portion of compact laminar structure from a stone composed of uric acid or the urates, when treated under the microscope with potassic solution, is certainly seen to clear after a time, more or less completely; but there remains behind a membranous matrix, often firm in consistence, which resists solution, and in the mass would not only impede the action of the alkali, but unless removed, would, it is probable, become a nidus for subsequent deposit. The weaker the solvent, the less and slower its action on such structures, and a

limit to it would soon be reached; and besides, it will commonly, if not always, be found that there are intermixed particles of calcic oxalate which remain unaffected. Formations mostly or entirely composed of the oxalate (which may be commoner in temperate climates than is supposed), would not, it is needless to add, be amenable to weak alkaline solvents; and even weak acid solutions, which have proved to be useful in removing deposits of the triple or mixed phosphates, would be of no avail when brought to act, under these circumstances, upon the intractable oxalate.

The electric current, short of inducing electrolysis, seems hardly more promising as a means of disintegrating calculi; a weak galvanic current, it has been ascertained, actually favours the production of submorphous forms, which under its influence make their appearance in a very much shorter period of time than usual (Bridgman, quoted by Bastian); and the magnetic current causes the crystals of calcium oxalate, formed in a colloid, to assume a much larger size than common (Ord).

Briefly, an acquaintance with the structural composition of calculi renders less probable than has been supposed, the utility of these several measures.

The prevention of stone.—Presuming that, in the main, urinary calculi are formed after the manner here described, it has now to be remarked that, by a change or reversal of conditions under which they were produced, calculous elements may be dissipated. Reference should be made to p. 37 for a short statement of the facts which Mr Rainey has, by experiment, clearly established; and I need in this place only repeat, as it is in

accordance with all known data to conclude, that if the conditions under which insoluble urinary salts assume the characters they present as calculous ingredients, be for a time changed, those ingredients will also alter their form, and, losing the sub-morphous structure, will revert to the state of granular *débris*. Let me again remark, so closely are conditions and results allied, that an alteration in the one promptly entails a corresponding change in the other; and so well founded does this axiom appear, that, joining with it a consideration of the facility with which various urinary ingredients may unite, while within the body, I regard the conclusion as highly probable that the seeds of "stone" (so to speak) are sown most freely during temporary derangements of the frame, but that under "improvement of health" (*i. e.* return of the urine to its normal characters) they become aborted and are destroyed. In this manner should I explain the comparative infrequency of "stone;" it will, however, happily be superfluous to enter into details in a matter so hypothetical as this may seem, if the views advanced in the present essay be sufficiently apprehended. I will only add that when a calculus exists, or is suspected to be present, the ordinary expression for this state being that there is a "tendency to stone," the object of rational treatment is clearly to effect a decided change in the characters of the urine, and to maintain such change for days or weeks, or even longer. As a matter of fact, this is the plan adopted when, with other subsidiary means, the prolonged use of a weak alkaline mineral water is prescribed; the efficacy of this course of treatment is, I suppose, tolerably well established in certain cases, and if attention in this place be directed

to the utility of inducing a change in the physical characters of the urine, rather than to the benefits of more constitutional measures, it is not because the latter are regarded as of little importance, for, as I have expressly stated above, it was not my intention to discuss any but the immediate conditions connected with "stone." It seems to me desirable, however, that the free habitual use of pure drinking-water be inculcated, whenever the visible characters of the urine are altered as they are in febrile, and allied disorders, the object being to dilute the urine, and to scour (as it were) the urinary passages from end to end.

Other indications of treatment, local and general, will appear on consideration of the facts and principles which have now been submitted; but without further comment on a topic which formed no part of my plan, I would conclude this essay by expressing a hope that some new light, at least, has in it been thrown upon certain points in the natural history of stone and the calculous disease.

DESCRIPTION OF PLATE I

Fig. 1.—Crystals of uric acid seen in the nuclei of small renal calculi, magnified ¼ in.; size $\frac{1}{800}$ to $\frac{1}{600}$ in.

Fig. 2.—Similar crystals, assuming a columnar form; from a urethral calculus.

Fig. 3.—Narrow elongated columns of uric acid, seen in a secondary layer of a larger calculus; magnified ¼ in.; diameter $\frac{1}{2800}$ to $\frac{1}{1600}$ in.

Fig. 4.—Piled crystals of uric acid, from the outer layer of a renal calculus. ¼-in. objective.

Fig. 5.—Similar crystals forming columns, from a urethral calculus, ¼ in.; diameter $\frac{1}{580}$ in.

Fig. 6.—Dissection of a small renal calculus, showing its formation by layers, which are either of an orange or a grey tint, in varying succession. The smaller figure is of the natural size, the larger a magnified view.

Fig. 7.—Part of a similar calculus, divided and magnified (1 in.). A lighter coloured layer is seen, differing in structure from the rest.

Fig. 8.—Nucleus of a similar calculus, showing crystals of uric acid. ¼-in objective.

Fig. 9.—Structure of the lighter coloured layer seen in fig. 7. ¼-in. objective.

Fig. 10.—Orange-coloured layer of a similar calculus, treated with liquor potassæ, showing dumb-bells, &c., of oxalate of lime, as contained within them. ¼-in. objective.

Fig. 11.—Crystals from the nucleus of a similar uric acid renal calculus, magnified ½ in. Liquor potassæ has been added. Some of the crystals have the appearance of octohedra.

Fig. 12.—Vesicles artificially produced by the action of liquor potassæ upon deposits of uric acid found in calculi. The darker ones are those first formed, and frequently the smaller opaque vesicles, seen below, precede the rest; ¼ in.; diameter $\frac{1}{8000}$ (of the smallest) to $\frac{1}{1000}$ in.

DESCRIPTION OF PLATE II.

Fig. 1.—Urates from the nucleus of a small calculus in the frequent state of granules. ¼-in objective.

Fig. 2.—Urates from the nucleus of a medium-sized calculus, showing large granules having the appearance of incipient globules. ¼-in. objective.

Fig. 3.—Various forms of acicular crystals (urates) from the nuclear portion of several calculi (¼ in.).

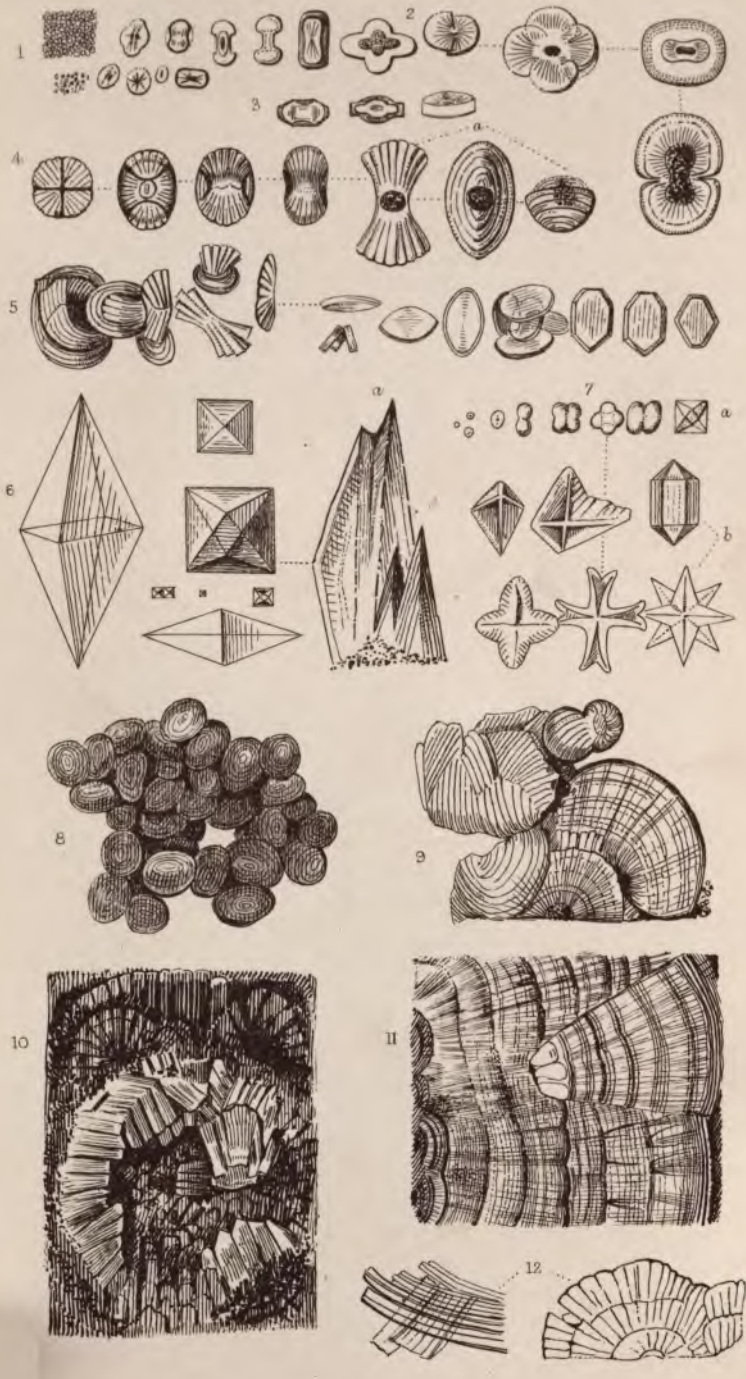
PLATE I.

STRUCTURAL ELEMENTS OF CALCULI — URIC ACID.

Dr H. V. Carter, del.

STRUCTURAL ELEMENTS OF CALCULI – THE URATES.

STRUCTURAL ELEMENTS OF CALCULI — OXALATE OF LIME.



er, del.

M. & N. Hanhart, lith.

Fig. 4.—Urates in a globular form, frequently seen to compose the central portion of calculi, and often imbedded in a granular matrix; ¼ in.; diameter $\frac{1}{4000}$ to $\frac{1}{1000}$ in. The globules not seldom show a concentric structure, and their shape may be angular from compression, &c.

Fig. 5.—A globule surrounded by spiculæ.

Fig. 6.—Globules partially blended and enveloped by spiculæ.

Fig. 7.—A globule acted on by acetic acid; previously to solution it showed a radiated structure.

Fig. 8.—A large flattened globule from near the centre of a calculus; ¼ in.; diameter $\frac{1}{400}$ in.

Fig. 9.—One from the outer layer of another calculus fringed with spiculæ; a few detached larger spiculæ are also shown.

Fig. 10.—Urates in the form of elongated filaments (length about $\frac{1}{700}$ in.), from the middle layers of a calculus. ¼ in.

Fig. 11.—A partly diagrammatic view of compact layers, composed of the urates, showing their formation from the globules.

Fig. 12.—Compact laminæ (urates), of varying thickness, from the layers of a calculus outside its nucleus. ¼ in.

Fig. 13.—Other laminæ, and a portion acted on by liquor potassæ, showing a few particles of oxalate of lime unacted on. ¼-in. objective.

Fig. 14.—A translucent chip from the nucleus of a urethral calculus, showing its composition of aggregated globules. ¼-in. objective.

Fig. 15.—Globules and laminæ from the outer layers of a calculus.

Fig. 16.—From the nucleus of a urethral calculus. At the bottom is seen a layer of clear oxalate of lime, marked *. ¼-in. objective.

Fig. 17.—A fragment from the nucleus of a urethral calculus acted on by liquor potassæ, showing persistent crystals (O. L.), disposed in a layer. ¼ in.

Fig. 18.—A similar fragment, from another large calculus, showing large octohedra, &c., of the oxalate of lime, unacted upon by liquor potassæ. ¼-in. objective.

DESCRIPTION OF PLATE III

Fig. 1.—Granular matrix, fine-grained, buff-tinted and uniform, in which spheroids were imbedded, from the nucleus of a calculus, and unaffected by acetic acid. ¼-in. objective (× 300 diams.).

Fig. 2.—Ovoid and dumb-bell crystals, from the interior of a small urethral calculus; long diam., $\frac{1}{4000}$ to $\frac{1}{600}$ in., or more, found mostly in a group and in connection with spheroids, &c. ¼-in. objective.

Fig. 3.—Similar crystals from the centre of a calculus, seen after the action of liquor potassæ, and imbedded in the urates. ¼-in. objective.

Fig. 4.—Spheroids of various forms and size, seen in the centre and

middle layers of large calculi, showing lines indicative of scales or lamellæ. The three figures marked *a* are of one fragment observed in different positions, and measuring $\frac{1}{1000}$ by $\frac{1}{800}$ in. $\frac{1}{4}$-in. objective.

Fig. 5.—Disintegrating spheroids and scales, from the centre of calculi. The diameter of the former was, at most, about $\frac{1}{800}$ in.; of the latter, $\frac{1}{2000}$ to $\frac{1}{1000}$ in., and thickness slight, some of an angular form being seen. $\frac{1}{4}$-in. objective.

Fig. 6.—Octohedra of various sizes, the largest from the nucleus of a calculus extracted from the bladder of a girl. Long diameter $\frac{1}{333}$ in. The group marked *a* from the crust of another calculus. $\frac{1}{4}$-in. objective.

Fig. 7.—Crystals of varying form and size, produced artificially from calculous material: *a*, by ignition, solution in nitric acid, and the addition of oxalate of ammonia; *b*, by the action of acetic acid first, then the addition of oxalate of ammonia. Other forms were seen. $\frac{1}{4}$-in. objective.

Fig. 8.—An agglomeration of spheroids, seen in the outer part of the tubercles of a large mulberry calculus, after the action of liquor potassæ. The average diameter of the spheroids was about $\frac{1}{800}$ in. $\frac{1}{4}$ in.

Fig. 9.—A group of spheroids, some passing into laminæ, taken from the nucleus of a very large calculus; + liquor potassæ. $\frac{1}{4}$-in. objective.

Fig. 10.—Centre of a hemp-seed calculus, the actual nucleus being probably composed of one or more spheroids. $\frac{1}{4}$-in. objective.

Fig. 11.—Clear crystalline laminæ, such as formed the mass of the same hemp-seed calculus, from near the centre. They are common. $\frac{1}{4}$-in. objective.

Fig. 12.—Similar laminæ from other calculi, showing their occasional decomposition in both a radial and concentric direction. $\frac{1}{4}$ in.

DESCRIPTION OF PLATE IV

Fig. 1.—Free crystals from the nuclei and central parts of various calculi; all were apparently of similar nature; the commoner forms only are shown; many were associated. Long diameter $\frac{1}{800}$ to $\frac{1}{300}$ in. or more, and thickness as variable ($\frac{1}{4}$ in.).

Fig. 2.—Groups of similar crystals: *a*, from the nucleus of a mulberry calculus, seen mostly edgeways, thickness $\frac{1}{5000}$ in. or more; *b*, from the outer layers of a small, pale, laminated calculus, granules interposing. $\frac{1}{4}$-in. objective.

Fig. 3.—Illustrations of the possible origin of these crystals: *a*, fragments from the nucleus of a small pale calculus; the segments indicated may separate and become free; diameter of the spheroid $\frac{1}{800}$ in.: *b*,

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PLATE IV.

STRUCTURAL ELEMENTS OF URINARY CALCULI.

PECULIAR CRYSTALS: PHOSPHATES.

Dr H. V. Carter, del

W. &

large octohedroid forms from the nucleus of a calculus; they are marked with lines indicating their structure, and the segments thus defined, becoming detached, would appear as free crystals (¼ in.).

Fig. 4.—Fragment of a small calculus: *a*, nuclear part, seemingly composed of dried blood and spheroids; *b*, a nest or pocket of free crystals, like those seen in fig. 1; *c*, disintegrating spheroids and scales resulting (¼ in.), drawn with the aid of camera lucida.

Fig. 5.—Structure of translucent layers found within a large hempseed caculus, the same as that furnishing figs. 10 and 11, Plate III. ¼-in. objective.

Fig. 6.—Fragment from the centre of a calculus (the same as that furnishing fig. 3 *b*, above), showing, besides a radiate disposition of octohedra, numerous free crystals, many of which resemble those seen in fig. 1. The dark part represents the urates in which all were imbedded. ¼-in. objective.

Fig. 7.—Phosphate of lime in compact crystalline form: *a*, *b*, *c*, from a large calculus found in a sac connected with the bladder (*vide* F. 10, Museum Royal College of Surgeons, London): *a*, as superimposed adherent plates; width of column $\frac{1}{500}$ in., thickness of plate $\frac{1}{4000}$ to $\frac{1}{2000}$ in.,* as acted on by acetic acid: *b*, as quadrilateral columns of smaller width, and formed of much thinner plates or lamellæ, vertically arranged; granular layers interpose between the columns: *c*, as aggregations of columns, varying in diameter from $\frac{1}{1500}$ to $\frac{1}{800}$ in., and exhibiting transverse markings: *d*, from the crust of other calculi (same Museum, Preps. A *c*, 1, and B *c*, 23), which had a radiate fibrous aspect. The narrow and slender lamellæ or plates are arranged in direction of the crystalline fibres, and sometimes appear to radiate; once an octohedron of the calcium oxalate was noticed*—a lamellar bundle during solution in acetic acid. ¼-in. objective.

Fig. 8.—Large crystals from the interior of a calculus; they had a granular aspect and rather tapering form (diameter $\frac{1}{1000}$ in.), and the square prisms were sometimes detached. Acetic acid dissolved them, but slowly. ¼-in. objective.

Fig. 9.—Some ordinary forms assumed by the triple phosphate in its compact state; the prisms are more or less blended, and have a diameter of $\frac{1}{1000}$ to $\frac{1}{800}$ in. Sometimes they seem to break up into smaller segments. All are rapidly and uniformly dissolved by acetic acid, leaving a distinct matrix marked*.

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